DEFENSE SCIENCE BOARD STUDY ON

21st Century Military Operations in a Complex Electromagnetic Environment

JULY 2015

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REPORT OF THE DEFENSE SCIENCE BOARD

STUDY ON

21st Century Military Operations in a Complex Electromagnetic Environment

July 2015

Office of the Under Secretary of Defense
for Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

This report is a product of the Defense Science Board (DSB).

The DSB is a Federal Advisory Committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense (DoD). The Defense Science Board Study on 21st Century Military Operations in a Complex Electromagnetic Environment completed its information-gathering in May 2014. The report was cleared for open publication by the DoD Office of Security Review on June 17, 2015.

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301–3140

DEFENSE SCIENCE BOARD

April 23, 2015

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY & LOGISTICS

SUBJECT: Final Report of the Defense Science Board (DSB) Study on 21st Century Military Operations in a Complex Electromagnetic Environment

I am pleased to forward the final report of the DSB Study on 21st Century Military Operations in a Complex Electromagnetic Environment.

The principal finding of the study is particularly sobering: At a time when the United States relies on information superiority on the battlefield for future military success, this capability is jeopardized by serious deficiencies in U.S. electronic warfare (EW) capabilities.

The study made several specific recommendations aimed at mitigating some of the most serious deficiencies in current systems. Also included are overarching recommendations addressing needs that are key to operating in a complex electromagnetic environment—dynamically managing use of the spectrum, achieving near real-time system adaptation, and shifting more to offense; and creating 21st century EW governance.

The cost to implement these recommendations is estimated at $2.3 billion per year for at least five years. The DSB understands that such an investment will be difficult to accommodate in this era of budgetary restraint but believes that failing to do so puts at serious risk the hundreds of billions of dollars invested in information dominance.

I encourage you to take appropriate action to implement the recommendations in this report.

Craig Fields
Chairman

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
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DEFENSE SCIENCE BOARD

April 20, 2015

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

Subject: Final Report of the Defense Science Board Summer Study on 21st Century Military Operations in a Complex Electromagnetic Environment

Attached is the final report of the 2013 Defense Science Board Summer Study. The study was tasked to examine both offensive and defensive electronic warfare (EW) needs and opportunities over the next two decades. The incentive for the investigation was a concern that while the U.S. is ever more dependent on the use of electronics to carry out operations, adversaries might use EW methods to challenge that use.

During the initial phase of the investigation, the study met with government agencies, military departments, laboratory researchers, and industry representatives. All offered a consistent theme that the U.S. was drifting into a decidedly lagging position in EW.

Early in the process, USD(AT&L) requested that the study provide some specific program needs and opportunities. In response, the study investigated EW in four operational support capabilities—satellite communications; tactical communications; precision navigation; and intelligence, surveillance, and reconnaissance; and also looked at three representative mission areas—tactical air combat, fleet defense, and ground force operations. Serious deficiencies were found in all seven areas. Worse, the study believes that such deficiencies are common to most military operational regimes.

Success in past conflicts has relied on information superiority on the field of conflict; this information superiority has been largely dependent on widespread use of modern sensor and communications electronics hardware and software. Unfortunately, that superiority in electronics is now severely challenged and a substantial set of initiatives is needed to regain the advantage.

The study finds the current position to be a consequence of three major factors. First is twenty-five years of EW neglect after the end of the Cold War. A perception that the threat had disappeared as well caused U.S. attention to EW to relax. Second is the worldwide migration of sophisticated electronics capabilities in hardware, software, and software-driven system architectures. As a result, the U.S. is no longer the overwhelming leader in these technologies. Finally, it has become clear that potential adversaries who have observed U.S. battlefield

electronics dominance in action are taking carefully orchestrated and well-funded steps to undo that advantage.

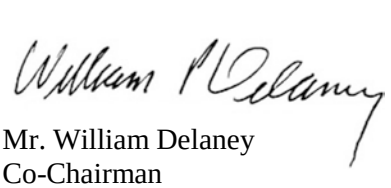
Three overarching needs emerged in the course of the study:

- First is the need to dynamically manage use of the electromagnetic spectrum. The U.S. lacks not only current situational awareness of the crowded spectrum, but also lacks the ability to dynamically make efficient use of the spectrum and to deny it to adversaries. This is a substantial technical challenge.
- Second is the need to achieve near real-time system adaptation. The speed at which modern digital electronics can shift operating modes and techniques has increased dramatically. The U.S. needs to adapt its use of EW hardware and software faster to keep up with the speed inherent in today's electronics.
- Third is the need to shift more to offense. The study determined that the U.S. cannot afford to patch every EW deficiency in all of its military warfare systems. To keep U.S. forces competitive, the U.S. needs to shift more to EW offense. This approach increases the burden on the adversary, imposes cost, and creates chaos in the adversary's environment. The U.S. can trade on that chaos for advantage in the fight. Specific recommendations are included in each of these three areas.

Finally, the study perceived that EW weaknesses stem in large part from a very serious deficiency in the Department's EW governance. If any of the recommended improvements are to have lasting value, the EW enterprise at the Departmental level must be reinvigorated. The study does not recommend a wholesale reorganization of the Department's treatment of EW, but instead recommends a modest change with two required elements—technical competence and clout. A high level EW Executive Committee (EXCOM) was recommended to provide the clout along with a modest supporting staff with technical and operational expertise. The exact form of this leadership is of course left to the Department, but clout and technical competence must be integral to any useful solution.

An overwhelming conclusion of the study is need for action. The stakes are high; the U.S. wins conflicts with information dominance but that dominance is being severely challenged. A restorative path is available, but will take funding, commitment, and a new spirit of leadership to close the growing gap.

Mr. Robert Stein
Co-Chairman



Mr. William Delaney
Co-Chairman

Abstract

High-end electronics technology that was once available only to defense system developers in a few large countries is today available worldwide and can be utilized by both large and small actors for electronic warfare (EW) capabilities. To address this situation, the Defense Science Board performed a year-long investigation of the ability to conduct U.S. military operations in a complex and congested electromagnetic environment. The study examined four operational support capabilities common to most military mission areas—tactical communications; satellite communications; positioning, navigation and timing (PNT); and intelligence, surveillance and reconnaissance (ISR). Three representative mission areas were also examined—tactical air combat, fleet defense, and ground warfare. Without exception, the ability to perform required functions and conduct required operations was seriously lacking in all seven areas in all but relatively benign EMS environments. Modern U.S. military operations base much of their success on the information dominance these abilities provide. Today, many countries, both near peers and regional powers, have the potential to limit the ability of U.S. systems to sense, communicate, network, and synchronize operations.

The study recommends several actions intended to mitigate the most critical deficiencies and vulnerabilities within the seven specific areas investigated. It is likely that looking at a more extensive set of mission and capability areas would have revealed similar issues in each. While addressing the individual deficiencies uncovered is important, the study also uncovered a number of foundational needs and strategies that underpin many areas of EW. Further recommendations treat these more ubiquitous deficiencies in three separate areas: 1) the need to manage use of the electromagnetic spectrum far better and more dynamically than today; 2) the need to adapt to EW-related events, either in terms of mitigating problems or taking advantage of opportunities, far faster than can currently be done; and 3) the need to shift more to offense because responding to every problem defensively will never get ahead of the adversary and is bound to be unaffordable.

Lastly, the study found that the U.S. EW governance has largely atrophied since the fall of the Former Soviet Union in the mistaken belief that the threat has gone away or is not as serious as it once was. The consequences of this lack of attention are serious and have manifested in numerous ways —a lack of appropriate institutional advocacy for EW as an important military capability; EW capabilities becoming a bill payer for platforms and other high visibility desires; test range facilities not keeping up with the threat; a lack of modeling and simulation capabilities above the one-on-one level; training and exercising only in relatively benign EW environments; and poor coordination and integration of needs and capabilities across EW as well as with other areas that impact EW capabilities. The study offers an modest organizational recommendation to revitalize the DoD EW enterprise to meet 21st century needs. While fully recognizing that organizational changes are difficult to implement, the study believes

that without action to restore the advocacy, oversight, coordination, and supporting infrastructure for EW, that the operational benefits of the preceding technical recommendations will be short lived.

The cost to implement the full set of recommendations is estimated at $2.3B per year for the next several years. While this level of investment will be difficult to find, the department needs to recognize that the expectation that U.S. forces will prevail in conflict relies to a large extent on information supremacy and that that supremacy will be lost if adversary EW capabilities can take away the ability to sense, communicate, navigate, and synchronize on the battlefield. Certain potential adversaries of the United States have much of that capability today and more will acquire it as modern electronics continues to be a global commodity. The study urges the Department to look at the recommended $2.3B annual investment as a modest insurance policy for the hundreds of billions of dollars of U.S. operational capabilities that depend on timely and accurate information.

Summary

In November 2012, the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) directed the Defense Science Board (DSB) to conduct a study of current and emerging electronic warfare (EW) techniques and capabilities that may face U.S. forces over the next two decades.' The study was also asked to evaluate EW techniques and capabilities that U.S. forces can utilize against potential adversaries and to examine at least one cycle of the measure, countermeasure, and counter-countermeasure cycle on both sides and the impact of such interactions on a representative set of important military capabilities across air, surface, underwater and space domains.

Several areas were suggested for consideration, including intelligence, surveillance and reconnaissance (ISR), command, control and communications (C3), weapon control, and positioning, navigation and timing (PNT). The terms of reference mentioned that the study membership might not be able to examine all of these areas, but to include as many needed to uncover major potential deficiencies, risks, and opportunities.

The terms of reference directs the study to produce a set of findings and recommendations to guide the development of new offensive and defensive EW capabilities. Improvements to specifying, testing, and evaluating future EW capabilities are also included, as well as guidance to the Department for developing modeling and simulation tools and capabilities to provide a Joint force-on-force campaign level examination and assessment.

To address this charge, the DSB called in members of the Board along with knowledgeable subject matter experts. The study met from July 2013 through May 2014, with their final outbrief in July 2014. During their year-long assessment, the study members focused on providing guidance, findings, and recommendations to assist the U.S. in retaining dominance in electronic warfare.

EW in Today's World

The U.S. has placed increasingly significant importance on information superiority as one of the keys to prevailing in conflict against other forces throughout the world. That superiority is built upon the sensing of ISR assets, the ability to communicate what these sensors see to all required elements of the fight, the geographic and temporal coordination of military forces, and using all of that to outmaneuver the actions of potential adversaries. The dependence on information has not gone unnoticed in the rest of the world and some adversaries have spent significant time, effort, and resources toward lessening the U.S. ability to gather, distribute, coordinate, and act on that information.

In addition to the increase in quantities of adversary systems, a qualitative change has occurred as a result of the worldwide availability of high-end electronics. EW systems can be described as "front end" analog systems that sense and receive information and "back end" digital data processing systems with functionality driven by software. A front end system with broad capabilities can be paired with modern electronics—as employed in radars, communications, and of particular concern here, jammers. A change in the back end software can dramatically improve the overall system capability, potentially in hours. For the adversary, that means a jammer can change its operating parameters, such as the

waveforms it radiates, techniques, or timing, within hours as what works and what does not work is observed on the battlefield.

The implications of this on U.S. operations are wide-ranging. These advances undermine the long-standing U.S. dependence on the exploitation of foreign systems as a way to determine adversary capabilities. There is no way to know whether an acquired system contains the latest software build or how many generations old it is. Similarly, observing radiated waveforms on adversary test ranges is not a dependable way of determining capabilities because embedded software capabilities are largely invisible.

These and other EW deficiencies are not new and have been highlighted by others in previous studies. In 2009, the U.S. Joint Electronic Warfare Center (JEWC), in an assessment of U.S. EW capabilities, identified 39 gaps. Fifteen were characterized as non-material and had to do with issues such as strategy, leadership, organization, and available EW expertise. The top three dealt specifically with the oversight of the EW enterprise in the U.S. Nineteen of the gaps were characterized as materiel and dealt with all of the functions of electronic warfare—electronic attack (EA), electronic support (ES), electronic protection (EP), and the use and management of the electromagnetic spectrum (EMS).

Study Organization

The study received briefings from a wide range of the defense community, including developers, testers, operators, intelligence agencies, and industry. After an initial assessment of general issues, challenges, and problems facing the Department, the study selected a representative set of capability and mission areas to aid in assessing how DoD is addressing electronic warfare. Four operational support capabilities that support most defense missions were selected along with three specific warfighting mission areas that depend on EW. While carrying out these assessments, the study identified foundational needs and strategies that apply to these and other areas in the EW enterprise. The study's technical findings and recommendations are divided into these three categories—EW capability functions, EW mission areas, and foundational needs and strategies.

Summary of Study Findings

While adversary EW capabilities vary widely today, these assessments are made in the context of an EW-capable adversary operating in a highly contested EW environment. Owing to the widespread and growing availability of modern and highly capable electronics throughout the world, adversaries with limited resources are increasingly able to present highly challenging EW environments to U.S. forces.

Many of the specific recommendations in this report are aimed at eliminating or mitigating the most serious vulnerabilities in each of these seven areas. These recommendations include minor system upgrades; new development efforts; procurement of some items that had previously been deferred or delayed; and a few one-year investigatory efforts in which the path forward was not clear. Those recommendations addressing these specific seven areas amount to slightly over $1.6 billion—about 70 percent of the total recommended $2.3 billion annual investment

Although a representative set of operational support capabilities and mission areas were reviewed, it was by no means complete. Because the deficiencies and vulnerabilities found were ubiquitous across the seven areas, the study felt that investigating other areas would have revealed similar issues. Thus, the recommended $1.6 billion for mission-specific improvements, although critically important, should not be viewed as complete. More is likely needed and it is hoped, as a result of improvements in governance of EW enterprise, they will be brought to light over the next few years.

Foundational Needs and Strategies

In examining the seven specific assessments, three somewhat broader technical capability needs arose. They are foundational in the sense that they apply to nearly all of the individual areas examined, and perhaps more importantly, underlie success on the EW battlefields of today and the future. Without them, the U.S. will forever find itself reacting to events beyond its control and trying to catch up. Recommendations in these three areas represent $500 million of the overall $2.3 billion in recommendations, or about 22 percent.

Managing Use of the Electromagnetic Spectrum

The Department's ability to effectively and efficiently use the relatively small amount of spectrum allocated to military operations is an issue. It was identified as a particularly severe issue for ground forces because of spectrum congestion, but it arose in other areas including tactical communications and tactical air combat. Part of the reason this has become an increasingly important issue over the past few decades is the continuing trend for the U.S. government to license portions of the spectrum for commercial uses. This results in competition within military users for what is left and the need for rapid temporal dynamics of who is using what on the battlefield. The increase in spectrum allocation and congestion over the past 40 years illustrates the need to improve the management of the electromagnetic spectrum for military, commercial, and civilian uses.

This dynamic management of the EMS is sometimes described as treating the spectrum as a "maneuver space." It is an interesting concept, because the EM maneuver space has two important characteristics it does not share with the four spatial domains. First, one can change frequency discontinuously and without trend, meaning that agility in the EM domain is possible in a way that is impossible in the four spatial domains. This agility is used in frequency hopping radios, but otherwise largely unexploited in U.S. systems today. It could be a critical enabler of future success.

A second factor is that any emission immediately impacts all other in-band devices within reach, meaning that all users share the EM spectrum in a way unlike the other domains. This sharing creates a physics-based imperative for the U.S. military to implement a unified approach to the governance and use of the EM spectrum to ensure that U.S. spectrum use is a force multiplier rather than a force canceller.

The objective of managing DoD's use of the spectrum is to dynamically enable U.S. forces to have unrestricted access to allocated spectrum while denying or disrupting the adversary's access. In order to accomplish that on the battlefield, widespread sensing; real-time collection and analysis; dynamic management and control of ES, EP, *and* EA functions are all needed. New tactics, techniques and

procedures and clear rules of engagement will need to be carefully thought out to allow DoD to manage its use of the spectrum. Unfortunately, none of these are present today—the best situation that exists today on the battlefield is static, pre-planned allocations. An effort is recommended to establish a higher level framework and rules, a near term, local management effort for the services and a longer term, wide-area, multiservice technology development.

Achieving Near Real-Time System Adaptation

The worldwide migration to digital, software-driven electronics provides a technical foundation for very rapid adaptation. For EW, this translates into a potential ability to change waveforms, techniques, and algorithms for large systems in hours or days, rather than today's normal cycle of years. The term "potential" is used because to exploit this potential, a number of issues must be addressed before systems can rapidly adapt. Some of these issues are the overall architecture of the system, the system software, the capability to record data in the field, and the availability of an analysis center to quickly provide actionable solutions.

To achieve a faster cycle, the notion of an "inner loop" inside of the normal 5 to 15 year acquisition loop is proposed. This faster cycle can provide this potential either to defensively mitigate problems as they arise or offensively respond to opportunities to exploit adversary weaknesses in near real time. The study's recommendations in this area include an assessment of current programs to determine adaptability needs and opportunities; the use of key performance parameters (KPPs) in competitive programs to measure and incentivize meaningful rapid adaptation; the creation of a mission inner-loop capability to enable near real-time adaptability; and the creation of a cross-service jamming techniques and analysis center modeled after the existing Navy's Jammer Technique Optimization Group (JATO) to support a broader range of operations.

Shifting More to Offense

As the study examined the issues, members were struck by the enormity of trying to defensively mitigate every potential EW vulnerability in current systems. Although clearly necessary for the most serious and ubiquitous weaknesses, such as GPS and satellite communications, the study believes a more balanced strategy is required, one that balances what DoD is doing on defense with measures to put an adversary more on the defensive as well. This "shift more to offense" has three primary objectives: (1) impose monetary cost on the adversary; (2) introduce chaos and uncertainty in adversary operations; (3) create the potential for negative consequences from adversary EA operations. Overall, this will allow U.S. forces to get ahead of adversaries in conducting EW operations and recapture the EW initiative on the battlefield.

Creating 21st Century EW Governance

In the course of the study, individuals representing different aspects of the EW community provided briefings—users and operators, testers, developers, analyzers, and industry representatives. What was most surprising was their common focus on a few organizational issues. Four primary themes emerged, reflecting in different ways an EW enterprise that has atrophied through neglect over the last quarter century.

- No ability exists to understand the potential impact of EW at a mission or force-on-force level. Programs can measure the impact at a one-on-one level in technical terms but the Military Services lack the ability to raise that to the mission level. This is a result of a lack of high-level analysis and modeling and simulation (M&S) capability, limited learning from EW-challenged exercising or training, an inadequate test range infrastructure and a well thought out interaction of how all three can complement each other.
- Although all levels of the Department have come to believe in the importance of information supremacy and the exploitation of that information in Joint, highly coordinated operations, there is little appreciation of the fragility of the underlying connectivity. This applies to connectivity between force elements, with space assets, with ISR assets, and with PNT sources.
- There is little recognition of how the worldwide migration to a digital, software-driven world and the availability of high-end electronics changes the EW paradigm of today. The fact that U.S. forces can be outmaneuvered on the battlefield through the EM spectrum they use, the waveforms they radiate, and the protective measures they employ is not widely appreciated. The phrase "EMS as a maneuver space" was heard repeatedly.
- Little coordination, advocacy, and oversight for EW exist across the Department. This is also partially a result of the fact that EW is not an entity in itself, it is an element of every radar, communications system, and jammer, and therefore EW is consistently two or three levels down from the platform. This enterprise-level lack of coordination has been called out repeatedly in the recent past, by reports from the Government Accountability Office (GAO) in July 2012, the U.S. Strategic Command (USSTRATCOM) and the Joint Electronic Warfare Center (JEWC) Electronic Warfare (EW) Capabilities Based Assessment (CBA), and the Initial Capabilities Document (ICD) and the Joint Electromagnetic Spectrum Operations (JEMSO) brief to this study

Fully recognizing that the most difficult recommendations to implement are those that have to do with organization and governance, the study firmly believes that this governance issue of oversight, coordination, and advocacy is important to address. If governance is not addressed, the impact of the other recommendations will be short lived and a future study of DoD's EW capabilities will find the Department in the same situation as today.

In order to correct this situation, an organizational construct is needed with two primary characteristics: first, the clout to make things happen when needed; and second, the technical and operational expertise to support that clout so that the right things happen rather than the wrong. After looking at a variety of potential constructs, and mindful of the need to minimize the financial and organizational burden of any new entity, the study settled on a high level Executive Committee (EXCOM). This organization should be jointly chaired by the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(AT&L)) and the Vice Chairman of the Joint Chiefs of Staff (VCJCS), supported by a roughly 15 person subject matter expert (SME) staff within USD(AT&L). Recommended funding is $100M for the staff function and an additional $50M to be used to enhance M&S, training and experimentation as appropriate. It is anticipated that not only will this revitalized governance function provide the required EW oversight, coordination, and advocacy, it will also ensure adequate treatment

of the many infrastructure deficiencies that were uncovered in this study, including (1) range improvements; (2) increased experimentation, learning, training, and exercising in EW-degraded environments; and (3) development of higher level EW modeling, simulation, and analysis capabilities.

While the study believes that establishing an EXCOM and supporting staff is the least burdensome way to achieve the clout and expertise required to coordinate, guide, and advocate for revitalized EW enterprise governance, the study also recognizes that there may be other ways of accomplishing the same goal. What is important is that it be accomplished with sufficient clout and with sufficient technical and operational expertise—not doing so will place DoD in a deficient position in the future with potentially disastrous consequences.

Budgeting for a new annual expenditure of over $2 billion in today's fiscal environment is very difficult. However, the U.S. military has invested hundreds of billions of dollars over the past few decades in achieving information superiority on the battlefield and the ability to use that information to achieve dominance against their adversaries. That strategy and the corresponding investment is now at risk because of the ability for adversaries of the United States to create their own offset strategy and take away the U.S. advantage. A commitment of $2.3 billion per year is viewed by this study as a relatively small down payment to ensure the continued success of U.S. strategy and the failure of U.S. adversaries' efforts to counter it.

Terms of Reference

ACQUISITION, TECHNOLOGY AND LOGISTICS

THE UNDER SECRETARY OF DEFENSE
3010 DEFENSE PENTAGON
WASHINGTON, DC 20301-3010

NOV 14 2012

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference – Defense Science Board 2013 Summer Study on 21st Century Military Operations in a Complex Electromagnetic Environment

Electronic Warfare (EW) has been used effectively as a critical element of warfare by the United States and other nations for the past 50 years. During the 1960s and early 1970s Vietnam conflict, U.S. forces used a variety of EW techniques to diminish the effectiveness of North Vietnamese single digit Surface-to-Air Missiles against U.S. aircraft operations over the country. There are numerous demonstrations in every domain (air, sea, ground, and space) over the intervening years of the advantage gained or lost by controlling the electromagnetic environment, including Israeli employment in the 1973 naval battle of Latakia; Hezbollah's employment of sophisticated elements of EW in the 2006 war with Israel; Russia's loss of several aircraft in the 2008 conflict with Georgia; and the U.S. experience in Iraq and Afghanistan combating the radio frequency detonated Improvised Explosive Devices.

Looking ahead to the future, the unprecedented global spread of highly sophisticated electronics technology will impact EW in many ways. In the coming decades, the Department must better understand how it can use advanced EW techniques to its advantage; how potential adversaries might use such techniques against us; and, in both cases, what effectiveness we might expect and what counter-measures might be used to limit such effectiveness.

The Defense Science Board (DSB) is requested to conduct a study of current and emerging EW techniques and capabilities that may face U.S. forces over the next 2 decades and EW techniques and capabilities that U.S. forces can utilize against potential adversaries. The study should examine at least one cycle of the measure, counter-measure, and counter-counter-measure cycle on both sides and should consider the impact of such interactions on a representative set of important military capabilities across air, surface, underwater, and space domains, such as intelligence, surveillance, and tracking; Command, Control, and Communications; weapon control; and Positioning, Navigation, and Timing.

While by necessity this examination will not be complete nor cover the totality of combinations of such capabilities and domains, it should encompass sufficient combinations to uncover major potential deficiencies, risks, and opportunities. In addition to examining EW capabilities at the individual technique level, the study should also consider how the Department can assess the value of such capabilities at a force-on-force or campaign level. Such examinations will provide insight on the value of techniques in combination with cyber and kinetic effects at a higher warfighting level, how combinations of techniques may be utilized to advantage, or what unintended disadvantageous consequences may occur in a complex multi-system environment that may not be obvious in "one-on-one" examinations.

The products of the study should be:

1. A set of findings and recommendations determined by the study to guide the development of new EW capabilities, both offensive and defensive, providing major leverage in potential future conflicts against both near-peer and regional powers. These capabilities should address the use of EW techniques across the full electromagnetic spectrum.

2. Guidance for the Department regarding what Modeling and Simulation tools and capabilities are required to examine the interaction of offense and defense EW capabilities at a joint force-on-force campaign level and an assessment as to whether or not such capabilities currently exist within the Department or need to be developed. The study should also provide a recommendation as to what organizations within the Department have the expertise and personnel resources to conduct or direct such work.

3. A set of findings and recommendations as to what improvements the Department can make in specifying, testing, and evaluating future EW capabilities, particularly when considering potential interactions, both intended and unintended, in complex environments or the action/reaction cycles discussed above.

A study subcommittee will be authorized access to relevant programs at all classification levels.

I will sponsor the study. Mr. Robert Stein and Mr. William Delaney will serve as co-chairmen of the Task Force. Mr. James MacStravic, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, will serve as Executive Secretary, and Lieutenant Colonel Mike Harvey, U.S. Air Force, will serve as the DSB Secretariat Representative.

The study will operate in accordance with the provisions of Public Law 92-463, "Federal Advisory Committee Act," and DoD Directive 5105.04, "DoD Federal Advisory Committee Management Program." It is not anticipated that this study will need to go into any "particular matters" within the meaning of title 18, United States Code, section 208, nor will it cause any member to be placed in the position of action as a procurement official.

Frank Kendall

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Study Chairs

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Mr. Robert Stein	Private Consultant

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Mr. Theodore Stump	Strategic Analysis, Inc.
Mr. Zachary VanSice	Strategic Analysis, Inc.
Ms. Emily Whitney	Virginia Tech Applied Research Corporation

Briefings to the Study

July 24-25, 2013

Presenter	*Organization*	*Topic*
Mr. Jeffrey Kula, Lt. Ronald Kemker, and Dr. Erik Thoreson	NASIC	Emerging Technologies in Electronic Warfare
Dr. William Chappell	DARPA	EW Innovation
Col James Pryor	U.S. Air Force	Air Force EW Review
Dr. Paul Zablocky	U.S. Army	Army EW Review
Mr. Jay Kistler	ASD(R&E)	Cyber/EW Convergence Study
LtCol Jason Schuette	U.S. Marine Corps	Marine Corps EW Review
Mr. Thomas Hayes	U.S. Navy	Navy EW Review

August 20-21, 2013

Presenter	*Organization*	*Topic*
Dr. J. Michael Gilmore	DOT&E	DoD Operational Test and Evaluation
Mr. Gerry Christenson	DoD	Defense Test Resource Management Center
BG Daniel J. O'Donahue	J8	Joint Requirements for Electronic Warfare
Col Stephen T. Ling	Joint Electronic Warfare Center	Capabilities Based Analysis

September 18-19, 2013

Presenter	*Organization*	*Topic*
Dr. Mark Tillman	DIA	Modeling and Simulation Overview
Dr. Mark Weiner	MIT Lincoln Laboratory	Advances in Air-to-Air Electronic Warfare Protection
Mr. Randall Walden	U.S. Air Force	Air Force Test and Evaluation
CAPT Steven Carden	U.S. Navy	Navy Air Dominance
Mr. Stuart F. Timerman	Defense Spectrum Organization	Spectrum Management

November 19-20, 2013

Presenters	*Organization*
Mr. Rick Martin, Mr. Darrell Uchima, and Mr. Brian Pelster	Boeing
Mr. Pat Antkowiak, Mr. Chuck Brinkman, Mr. Michael Johnson, Mr. John McCreesh, Ms. Tami Randolph, and Mr. Neil Siegel	Northrop Grumman
Mr. Jason Clark, Mr. Neil Kacena, Mr. William Kiczuk, Mr. Daniel Rypysc, Mr. Brad Whittington, Mr. Shu Ho, and Mr. Ronald Klinger	Raytheon
Mr. Patrick Ballester, Mr. Mark Drinhaus, Mr. Michael Panczenko, Mr. J. Scott Rodgers, and Mr. Robert White	Lockheed Martin
Mr. Murray Collette, Mr. David Logan, Mr. Leonard Lublin, Mr. David Subisak, Mr. Brian Walters, and Mr. Jerry Wohletz	BAE Systems

December 10-11, 2013

Presenter	*Organization*	*Topic*
Dr. Will Roper	Special Capabilities Office	DoD Strategic Capabilities
Dr. James Marshall	MITRE	EA Vulnerabilities and Anti-Jam Capable Communications

January 6-9, 2014

Presenter	*Organization*	*Topic*
Dr. James Chow, Mr. Michael Rigoni, and Mr. Scott Stadler	Air Force Scientific Advisory Board	Study on Airborne Networking and Communications for Contested Environments
Ms. Ellen Purdy and Mr. Benjamin Riley	ASD(R&E)	Electromagnetic Spectrum Consortium

February 11-13, 2014

Presenter	*Organization*	*Topic*
Mr. Bryan Larocca	AFLCMC/EZJA	Air Force EW Analysis
Mr. Michael Miles	Booz Allen Hamilton	Air Force EW Analysis
Dr. Stewart Cameron	NRO	NRO SAO
Mr. William Dooley	NAVAIR 4.1.8.1	Navy Modeling, Simulation, and Analysis
Mr. Keith Gentile	L-3 Communications	Overview
Mr. Frederick Moorefield	OSD/C10	Spectrum Management
CDR Robert Croxson	CAPE	Next Generation Jammer

March 11-12, 2014

Presenter	*Organization*	*Topic*
CDR J. Lee Jackson	U.S. Navy	Navy Analysis of Alternatives